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Status of the "Hot Cell"

Ellipsometric Studies

The "Hot Cell" was needed to study semiconductor surfaces at elevated temperatures in an atmosphere of a mixture of argon and hydrogen gases. The temperatures of interest were believed to range from 20°C to a maximum of 150°C. To meet this need a brass cell was assembled using soft solder. As shown in Figs. ~~1 and 2~~ four windows were mounted on the cell. Two reflection configurations from the sample were then possible by utilizing three of the windows in different pairs. One configuration allows for use at an angle of incidence of 67.5° and the other permits use at an angle of incidence of 45°. The 67.5° arrangement which is most frequently used can be very difficult to align. The fourth window mounted opposite the sample mount greatly facilitates this alignment by allowing the direct observation of the beam spot position on the sample. As Figs. 1 and 2 indicate the windows are mounted on flanges that are attached to the body of the cell through formed steel bellows.

Cell temperature can be elevated by use of a 100 watt cartridge heater embedded in the copper sample mount as shown in Fig. 3. In the presence of the Ar-H2 gas circulatation this heater can raise the temperature of the cell to the desired 150°C. However, the cell does act as a heat sink with a huge heat capacity. Heat is conducted to the top of the cell by the circulating gas and the entire cell is heated. This necessitates the use of Kalrez O-rings to withstand the high temperature.

Accompanied in Fig. 4 are the results of the real and imaginary parts of the pseudodielectric constants as a function of photon energy obtained from a trial run on a CdTe sample at different temperatures. The sensitivity of these measurements to sample temperature is an encouraging sign for the potential of

this ellipsometric technique for studying the temperature dependence of semiconductor surfaces.

On a recent visit Dr. Unchul Lee proposed the desirability of extending the maximum temperature for the temperature studies to 250°C. This was impossible with the existing design of the cell. First, the current heater could not heat the sample to that temperature. Moverover, even if a larger cartridge could be accommodated in the cell, the soft solder would melt at approximately 200°C. Changing the solder would amount to building a new cell. Consequently it was decided to heat the samples under vacuum.

Since the visit of Dr. Lee, a new vacuum jacket has been built that will mount on top of the cell, A sketch of the jacket is shown in Fig. 3. In addition to allow heating of the sample, the jacket will allow the sample to be cooled to liquid nitrogen temperatures. A vacuum system has been assembled as well, including a diffusion pump and a cold trap. This system is operational. Since the cell originally was not designed for vacuum, the formed bellows proved very difficult to seal. Moreover, the connection of the cell to the pump had to be made with wet seals that allow the rotation of the cell in measuring the angle of incidence. At present, "cell and vacuum system" together are being tested. It remains to be seen if the vibrations of the pumping system will affect our ellipsometric measurements.

The best vacuum that we can acheive in the cell is of the order of 10^{-4} torr. This will need to be improved. A new cell made of stainless steel pumped by turpo vacuum, pump is under study. Construction of such a cell will yield a much cleaner system than what a brass cell can provide.

Figure 1. Side view of cell.

Figure 2. Top view of cell with new observation window.

Figure 3. The vacuum jacket.

Figure 4. The results obtained by heating a CdTe sample to 150°. The black curve shows ε_1 and ε_2 at room temperature; the dotted blue curve shows ε_1 and ε_2 at 150° one hour after the heating started. The rest of the blue curves are for ε_1 and ε_2 at 150°C 2, 3 1/5 and 4 hours after heating started. The red curve is after the sample had cooled back to room temperature.

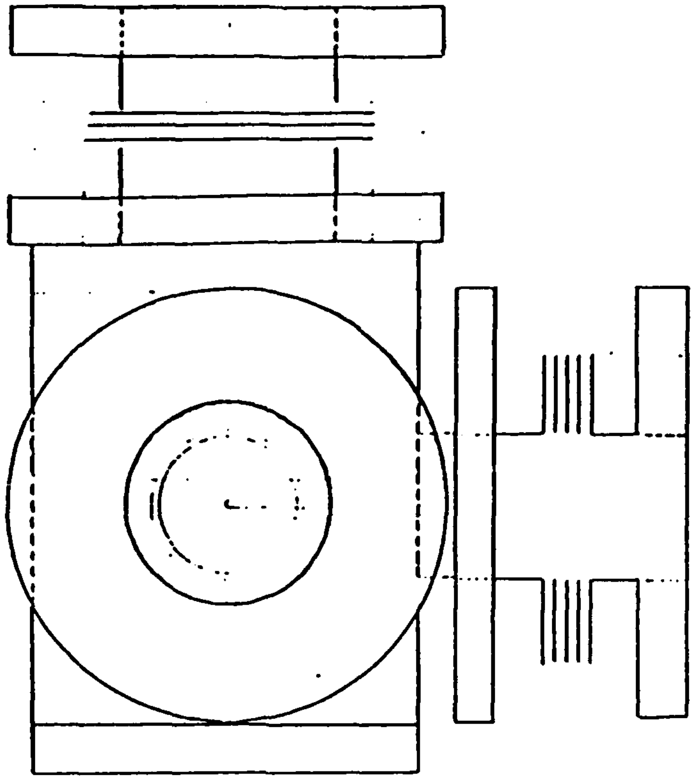
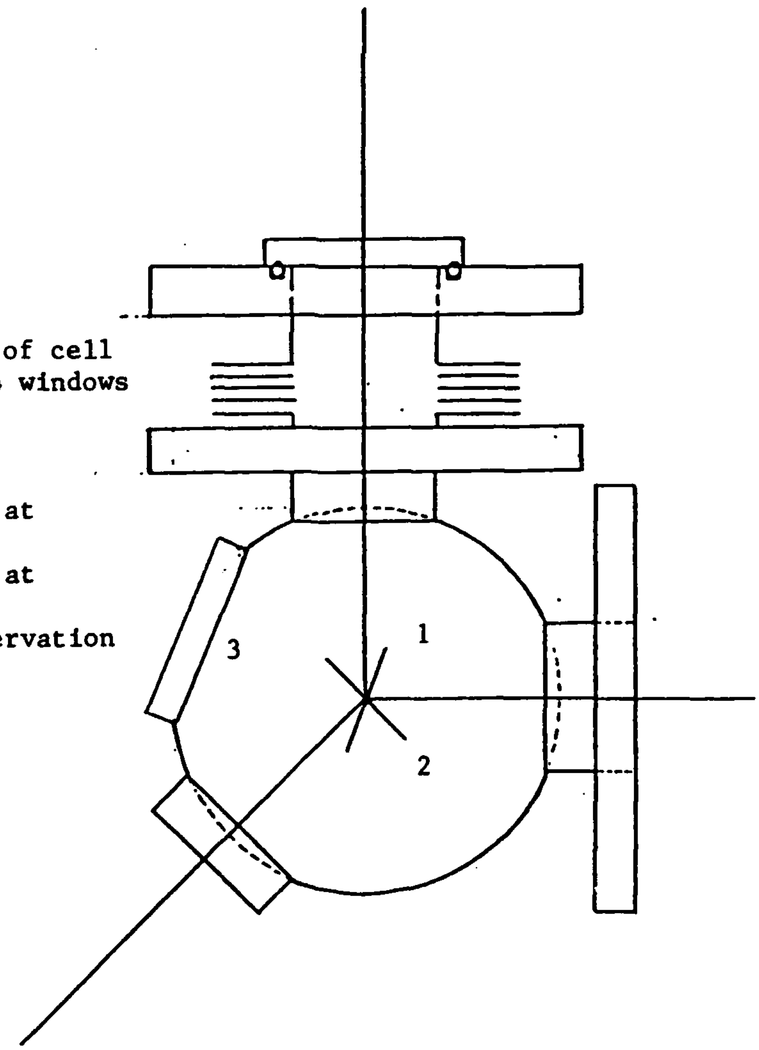


FIGURE 1: Side view of cell showing 2 windows only. Top Flange is used to mount heater and is provided with bellows to tilt sample inside cell.

Figure 2: Top view of cell showing 4 windows

1. Sample position at 67.5° incidence
2. Sample position at 45° incidence
3. Position of observation window



1 = Stainless steel dewer capacity ~
   1 liter of liquid nitrogen

2 = Vacuum

3 = Sample

4 = Heater cartridge

5 = Kalrez O-Ring

6 = Heater wires

7 = To vacuum pump

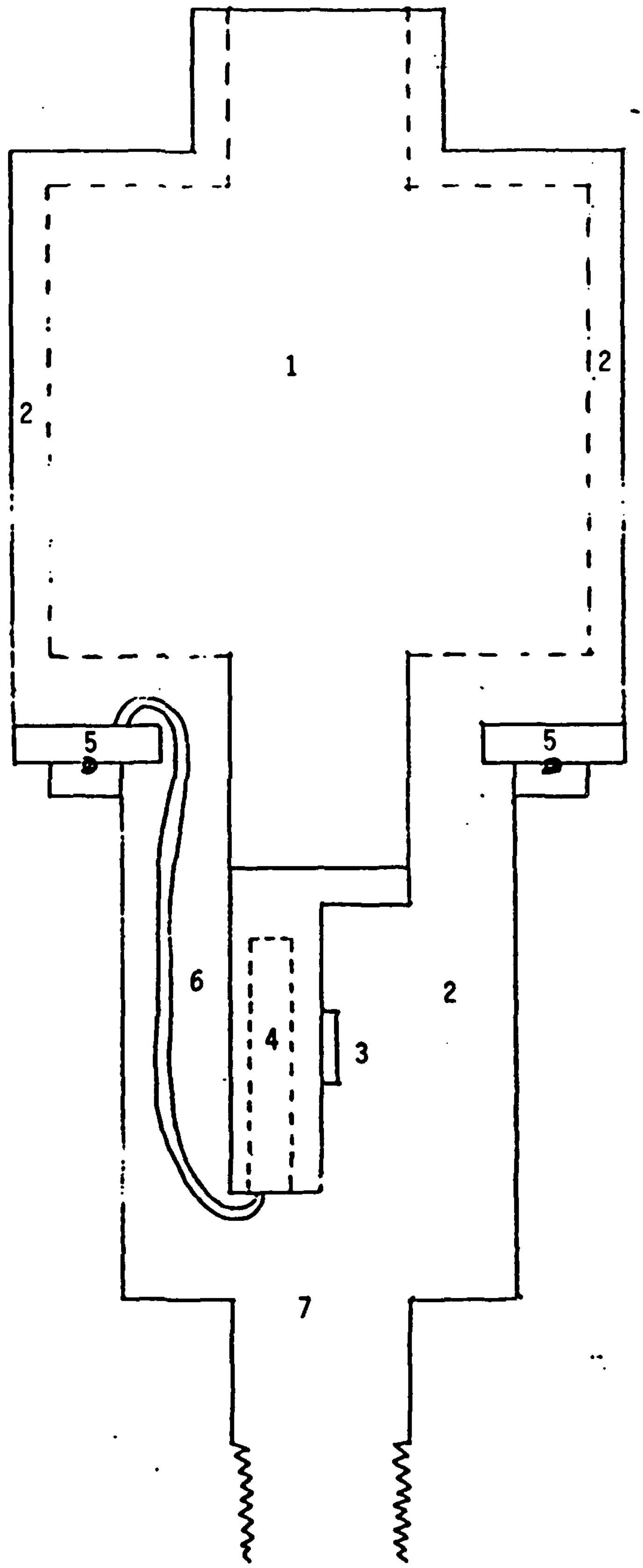
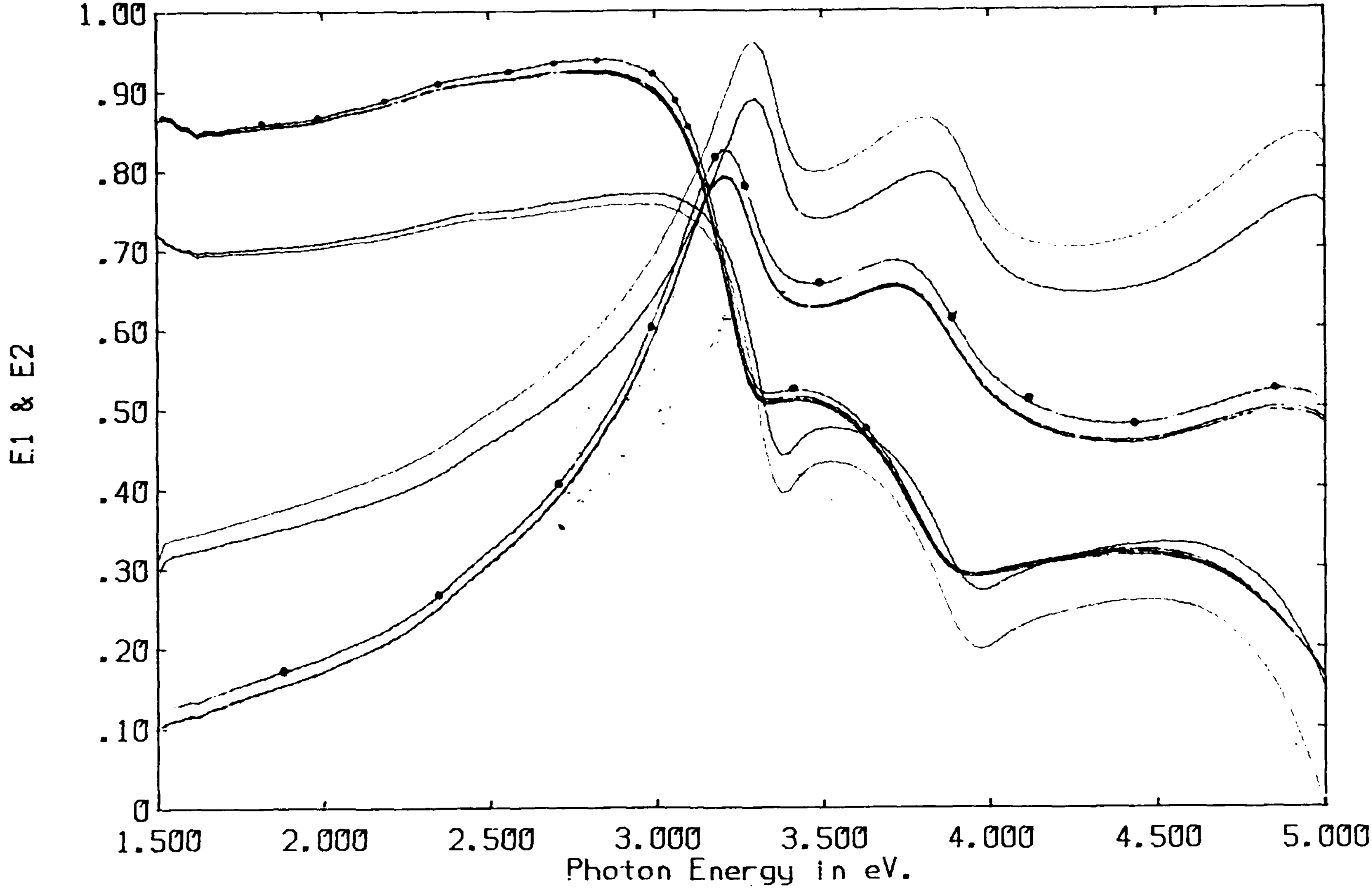


FIGURE 3

CdTe sample June 10th curves for E1 & E2 at room temp for black and red and at 150 degrees for blue



Scale = 10 1

Figure 4.

Readings Averaged: 10